CHIP-8 Classic Manual

Revision 1.6
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www.CHIP-8.com

CHIP-8 INTRODUCTION

CHIP-8 was originally developed by RCA Labs (1972) to allow users of low cost microcomputers to design their own video game programs without the tedious task of writing assembly language programs. RCA's original Computer was called the Cosmac VIP. It used an 8 Bit processor (1802) running at 1.76 Mhz.
Sound consisted of one fixed tone, and data storage utilized a cassette recorder.

This modern day implementation of a CHIP-8 Computer has a Flash based Interpreter that is resident within the boards Operating System.

The Hardware specifications are:

- ♦ 32 BIT Microcontroller running at 48MHz.
- ♦ 64x32 pixel monochrome Composite Video Display.
- ♦ Sound Generator – 30 Tones.
- ♦ RS485 Serial Port.
- ♦ Hexadecimal Keypad Interface.
- ♦ EEPROM Option board – CHIP-8 supported Load and Save functions.
- ♦ Single 7.5VDC Supply, using a 2.1x5.5 DC plug
- ♦ Small 120x90mm PCA footprint.

The CHIP-8 language has 41 instructions, including 3 new instructions which support RS485 Serial Communications, and Sound Generator Pitch changes.

The language uses 16 one-byte registers (V0 – VF), which can be manipulated with a variety of arithmetic/logic and conditional branch instructions. A 12 BIT Instruction pointer (I) indexes memory locations for load/store and display instructions. This allows multiple sets of variables or array processing. Subroutine nesting is implemented to 32 levels.

Figure 1: CHIP-8 Interface Connectors

Figure 2: CHIP-8 Hexadecimal Keypad

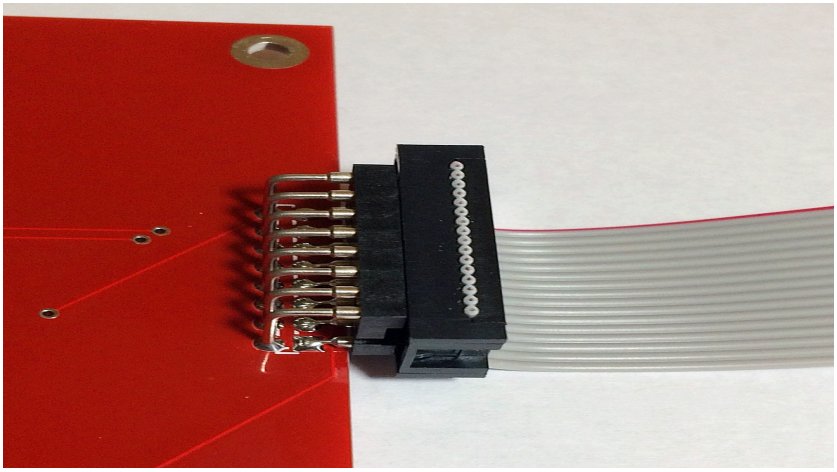

Figure 3: Keypad – Connector orientation

START UP

The CHIP-8 board has three modes of operation – Command Mode, Edit Mode, and Program mode. When power is first applied, you start off in Command mode. The display shows random data within the active display area.
The white Status Bar, located towards the bottom of the screen shows the hexadecimal numbers 4457. This is the normal default value prior to the address being changed.

Figure 4: CHIP-8 Display

STATUS BAR

The white status bar shows the current memory address being pointed to by the CHIP-8 program counter (PC). It is a four digit Hexadecimal number. The value can range from 0000 to FFFF Hex.

When in edit mode a two digit Hexadecimal number is displayed to the right of the memory address. This value represents the data being pointed to by the progam counter.

COMMANDS

You must be in Command mode to use the Function keys.

Pressing the F2 key will reset the monitor. The boards Red LED will light. Program data is not lost. When in edit mode, pressing the F2 key allows the monitor to break out and go back to command mode.

Pressing the F1 key followed by the 0 key will place the monitor into edit mode. It is this mode that allows a program to be stored in memory. Pressing the F1 key when in edit mode will increment the address of the program.

Pressing the F1 key followed by the 1 key will save a program to EEPROM. All data between addresses 0200 Hex and 09FF Hex will be saved.

Pressing the F1 key followed by the 2 key will load a previously saved program to CHIP-8 memory beginning at address 0200 Hex.

Pressing the F1 key followed by the 3 key will tell the monitor to run the CHIP-8 program starting at address 0200 Hex. This is the third mode of operation.

Commands (F1,1) and (F1,2) rely on the EEPROM Option board being installed .

CHIP-8 INSTRUCTION SET

Stored Code	Mnemonic	Description
0000	NOP	No Operation.
00E0	ERASE	Clear the Screen.
00EE	RETURN	Return from Subroutine.
1MMM	GOTO MMM	Jump to location MMM.
2MMM	DO MMM	Call Subroutine.
3XKK	SKF VX=KK	Skip next Instruction if VX=KK.
4XKK	SKF VX≠KK	Skip next Instruction if VX≠KK.
5XY0	SKF VX=VY	Skip next Instruction if VX=VY.
6XKK	VX=KK	Assign Hex value KK to Register VX.
7XKK	VX=VX+KK	Add KK to VX.
8XY0	VX=VY	Copy VY to VX.
8XY1	VX=VX | VY	Logical OR VX with VY.
8XY2	VX=VX.VY	Logical AND VX with VY.
8XY3	VX=VX XOR VY	Logical XOR VX with VY.
8XY4	VX=VX+VY	Add VY to VX.If result >FF, then VF=1.
8XY5	VX=VX-VY	Subtract VY. If VX<VY, then VF=0.
8XY6	VX=VY SHR 1	R.Shift VY. Result in VX. If LSB=1,VF=1.
8XY7	VX=VY-VX	Subtract VX.If VY<VX, then VF=0.
8XYE	VX=VX SHL 1	L.Shift VY. Result in VX. If MSB=1,VF=1.
9XY0	SKF VX≠VY	Skip next Instruction if VX≠VY.
AMMM	I=MMM	Set memory Index Pointer to MMM.
BMMM	GOTO MMM+V0	Jump to location MMM+V0.
CXKK	VX=RND.KK	Get random byte, then AND with KK.
DXYN	SHOW N@VX,VY	Display N-byte pattern at (VX,VY).
EX9E	SKF VX=KEY	Skip if key down =VX. No wait.
EXA1	SKF VX≠KEY	Skip if key down ≠VX. No wait.
F000	STOP	Jump to Monitor (CHIPOS).
FX07	VX=TIME	Get current timer value.
FX0A	VX=KEY	Input Hex key code. Wait for key down.
FX15	TIME=VX	Initialize Timer. 01=20 mS.
FX17	PITCH=VX	Set the Pitch of the Tone Generator to VX.
FX18	TONE=VX	Sound Tone for 20 timesVX milliseconds.
FX1E	I=I+VX	Add VX to Memory Pointer.
FX29	I=DSP,VX	Set Pointer to show VX (LS digit).
FX2A	I=DSP,VX	Set Pointer to show VX (ASCII character).
FX33	MI=DEQ,VX	Store 3 digit decimal equivalent of VX.

Stored Code	Mnemonic	Description
FX55	MI=VO:VX	Store V0 through VX at I. I=I+X+1.
FX65	V0:VX=MI	Load V0 through VX at I. I=I+X+1.
FX70	RS485=VX	Send data in VX to RS485 Port.
FX71	VX=RS485	Waits for received RS485 data. Place in VX.
FX72	BAUD=VX	Set RS485 Baud rate.

BAUD RATES

Data	BAUD Rate
0x00	110 BAUD
0x01	300 BAUD
0x02	1200 BAUD
0x03	2400 BAUD
0x04	4800 BAUD
0x05	9600 BAUD
0x06	19200 BAUD
0x07	38400 BAUD
0x08	57600 BAUD
0x09	115200 BAUD

The default Baud rate is 9600.

Note: When using the FX71 instruction to receive RS485 data, the transmit data must be delayed by a minimum of 300mS to allow for a successful read to occur.

PITCH VALUES

Data	Note	Frequency
0x00	No Tone	0 Hz
0x01	Note C2	65 Hz
0x02	Note D2	73 Hz
0x03	Note E2	82 Hz
0x04	Note F2	87 Hz
0x05	Note G2	98 Hz
0x06	Note A3	110 Hz
0x07	Note B3	123 Hz
0x08	Note C3	131 Hz
0x09	Note D3	147 Hz
0x0A	Note E3	165 Hz
0x0B	Note F3	175 Hz
0x0C	Note G3	196 Hz
0x0D	Note A4	220 Hz
0x0E	Note B4	247 Hz
0x0F	Note C4	262 Hz
0x10	Note D4	294 Hz
0x11	Note E4	330 Hz
0x12	Note F4	349 Hz
0x13	Note G4	392 Hz
0x14	Note A5	440 Hz
0x15	Note B5	494 Hz
0x16	Note C5	523 Hz
0x17	Note D5	587 Hz
0x18	Note E5	659 Hz
0x19	Note F5	698 Hz
0x1A	Note G5	784 Hz
0x1B	Note A6	880 Hz
0x1C	Note B6	988 Hz
0x1D	Note C6	1.047 KHz

CHIP-8 MEMORY MAP

Address Range (Hex)	Function
0000 – 003F	Stack
0040 – 004C	Scratchpad
004D – 00FF	Unused
0100 – 01FF	Display
0200 – 0FFF	Program area

Scratchpad area:

0040H – Firmware Revision (2 bytes).
0048H – EEPROM Unique ID (8 bytes).

SCHEMATICS

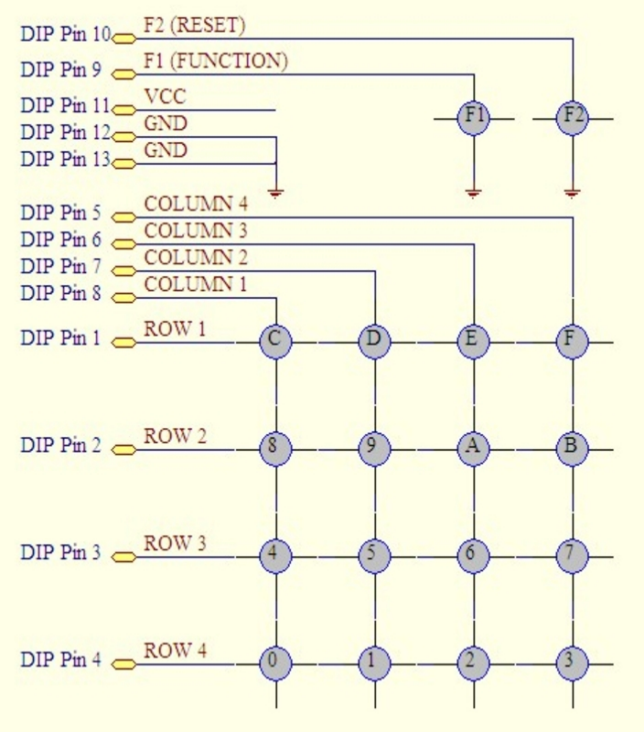

Figure 5: Hexadecimal Keypad

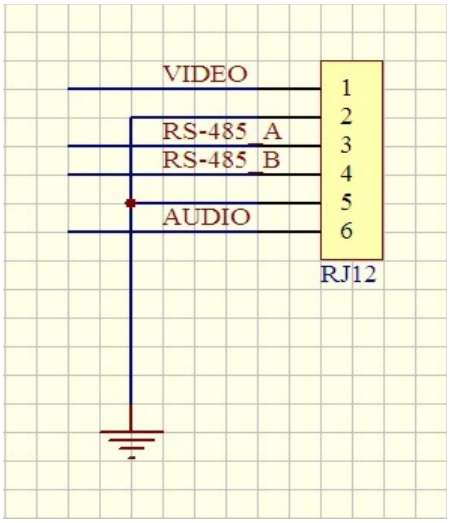

Figure 6: Display/Comms Interface

OPTION BOARDS

BREAKOUT BOARD:

Converts the RJ12 Signals to individual Composite Video, Audio and RS-485 Connections.

The board plugs into the CHIP-8 processor boards RJ12 connector. The two boards are interfaced via a short length of RJ12 cable (supplied with the Breakout board).

Video is provided on the Yellow RCA Connector.
Audio is provided on the White RCA Connector.
The RS-485 Differential Pair, and a common ground is provided on the Green 3 pin Terminal block.
The 2 pin jumper enables the RS-485 line termination.

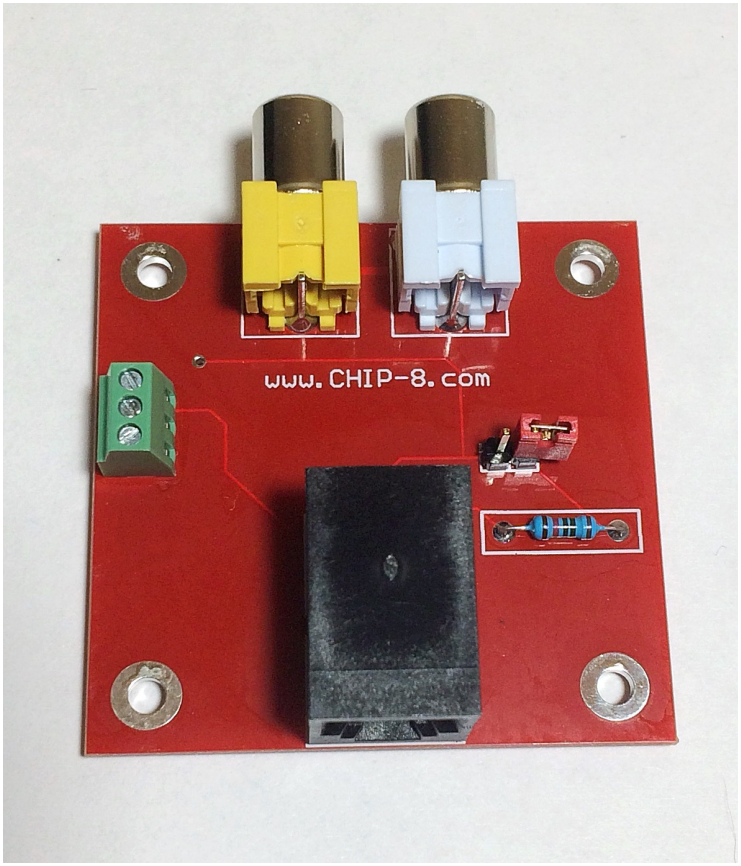

Figure 6: Display/Comms Interface

EEPROM BOARD:

The EEPROM board allows the user to load, and save CHIP-8 programs. The EEPROM capacity is 2K bytes, which is an enormous amount of storage for a CHIP-8 program.

The board plugs into the 5 pin header located on the top left side of the CHIP-8 processor board, and can be easily swapped out when the power supply is disconnected. Figure 7 shows the correct board orientation.

Only one program can be saved in each EEPROM board.
If multiple programs were required to be saved, it would require more than one EEPROM board to be available.

To SAVE a program, enter Command mode then press the F1 key followed by the 1 key.
To LOAD a program, enter Command mode then press the F1 key followed by the 2 key.

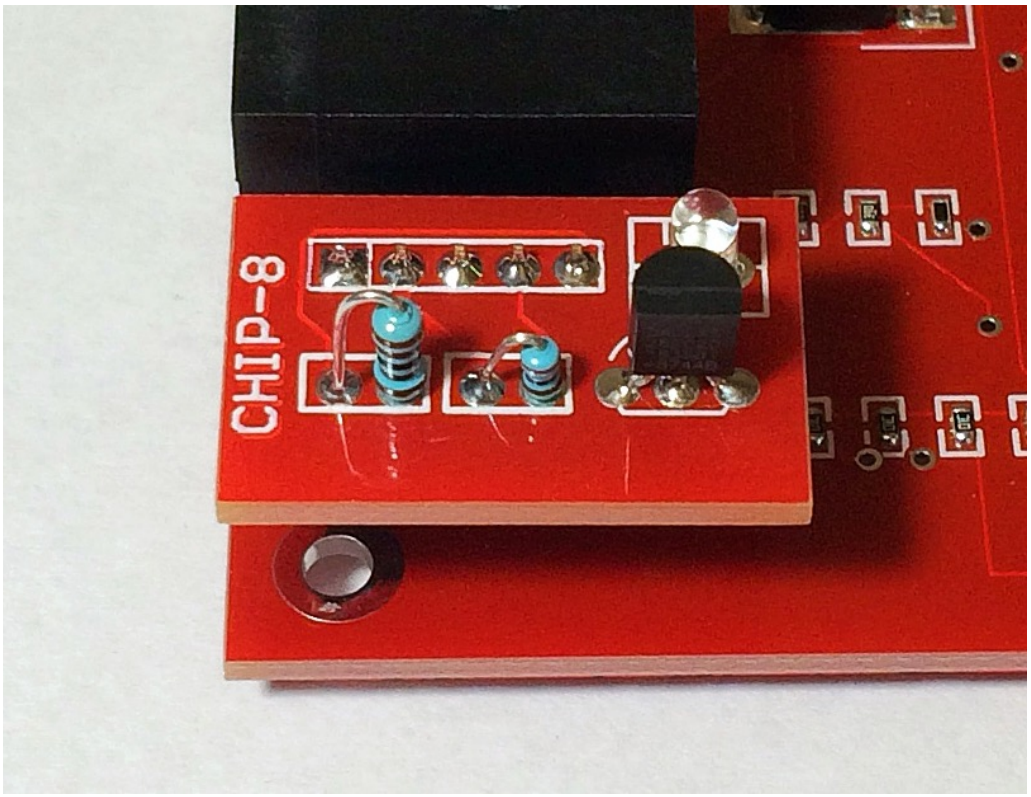

Figure 7: EEPROM Board

CHIP-8 PROGRAMMING

WRITING YOUR FIRST CHIP-8 PROGRAM:

From COMMAND mode, enter 0200 on the keypad.

Enter EDIT mode (Press the F1 key, followed by the 0 key).

Enter data 00E0.

On the display you will see that the address has auto incremented to 0202H.

Enter data F000.

Press the F2 key, to return to COMMAND mode.

Press the F1 key, followed by the 3 key to run the code.

CONGRATULATIONS! You just ran your first CHIP-8 program...

The program code for what you just did is shown in this format:

0200:	00E0	Clear the Screen.
	F000	Return to Monitor.

The 2nd line of the code, returns the processor back to the Monitor.

This is an important step because it gives you the ability to execute further Monitor commands.

CLEARING THE DISPLAY:

Use the 00E0 instruction.

You may have noticed - When the CHIP-8 computer is first turned on, the Screen contains random data.
Prior to writing your own programs that utilize the display, you will want to clear the screen of any rubbish that doesn't need to be there.

WRITING A CHARACTER TO THE SCREEN:

CHIP-8 display characters are called Sprites.
Prior to writing a Sprite to the screen - The CHIP-8 Interpreter first looks to see what Sprite is already at the pointed to Screen co-ordinates.
It then XOR's this data with the new data, and places the result on the display.

Because of this, rewriting a Sprite to the same location also erases the Sprite. This is useful for Game animation.

The CHIP-8 display has a resolution of 64 by 32 pixels.

The screens origin is at the top left corner, at screen XY co-ordinates (0,0).

X co-ordinates range from 0 to 3FH, and Y co-ordinates range from 0 to 1FH.

The following code outlines the Sprite drawing process, where a Sprite (X) is drawn at Screen co-ordinates 0,0:

```
0200:   00E0   Clear the Screen.
        6000   Set X co-ordinate.
        6100   Set Y co-ordinate.
        A300   Set Sprite location.
        D015   Draw Sprite.
        F000   Return to Monitor.

0300:   2112
        0C12
        2100
```

To draw the Sprite at a different Screen location - change registers V0, and V1.
For example, changing V0 to 01H moves the Sprite one pixel to the right.

The Sprites pattern is located at address 0300H. In this case - 5 bytes of data.

The DXYN instruction can write up to 15 bytes at a time. Therefore, the Sprite could be up to 8 pixels by 15 pixels.

Larger Sprites can be created by executing the DXYN instruction multiple times.

WRITING A HEXADECIMAL NUMBER TO THE SCREEN:

Use the FX29 Instruction.

The CHIP-8 Interpreter has in-built Fonts for the Hexadecimal numbers 0 through F. Font size is 4 by 5 pixels.

Simply place the hex value in a register (V0-VF), and reference that register using the FX29 instruction prior to drawing the Sprite.

Here is a program example:

```
0200:   00E0    Clear the Screen.
        6000    Set X co-ordinate.
        6100    Set y co-ordinate.
        620A    Put number in V2.
        F229    Point to the A font.
        D015    Draw Sprite.
        F000    Return to Monitor.
```

A different number can be written to the screen by changing the contents of V2.

SENDING DATA OUT THE RS-485 PORT:

First of all you set up the Baud rate, then transmit the data.

All tranmissions will be 8 data bits, no parity, 1 stop bit.

Here is a program example:

```
0200:   6009
        F072    Set Baud rate to 115,200.
        6031
        F070    Send the ASCII character (1).
```

RECIEVING RS-485 DATA:

Use the FX71 command.

When the processor encounters this command it will wait until a byte of data is received on the RS-485 port.
The data is placed in the specified register.

Here is a program example:

```
0200:   F071   Wait for RS-485 data.
        3031   Skip if its the ASCII character (1).
        F000   Return to the Monitor.
        1300   Jump to the Receive data routine.
```

Is there an easy way of decrementing a Register?

Use the 7XKK Instruction, to add FFH to the number.

Here is an example:

```
0200:   6A29   Load VA with 29H.
        7AFF   Add FFH to VA.
```

After running this code, VA=28H.

ANIMATING A SPRITE:

Sprite animation is performed by capitalizing on Persistance of Vision.

Firstly, draw a Sprite to a screen co-ordinate. Now - erase the Sprite.
Move the Sprite to an adjacent Screen co-ordinate, and perform the same actions.
Its also helpful to call a delay after drawing, as the routine happens very quickly.

This code demonstrates the process:

```
0200:   00E0    Clear the Screen.
        6A00    Set the X co-ordinate to 00H.
        6B00    Set the Y co-ordinate to 00H.
        2400    Draw SPRITE A.
        2500    Keep on the Screen for a moment.
        2400    Erase the Sprite. (XOR with the previously drawn Sprite).
        2500    Call delay.
        7A01    Increment X to the next Screen position.
        2600    Draw SPRITE B.
        2500    Keep on the Screen for a moment.
        2600    Erase the Sprite.
        2500    Call delay.
        7A01    Increment X.
        1206    Keep animating the Sprite.

0300:   BA7C    Sprite A data.
        D6FE
        54AA

0310:   7C7C    Sprite B data.
        D6FE
        546C

0400:   A300    Sprite A Address.
        DAB6    Draw Sprite A.
        00EE    Return.

0500:   6600    Delay Routine - clear V6.
0502:   7601    Increment V6 - Outer delay loop.
        6500    Clear V5.
```

```
0506:   7501    Increment V5 - Inner delay loop.

        3508    Skip if V5=08H.
        1506    Jump to 0506H.
        36A0    Skip if V6=A0H.
        1502    Jump to 0502H.
        00EE    Return.

0600:   A310    Sprite B Address.
        DAB6    Draw Sprite B.
        00EE    Return.
```

CHECKING THE FIRMWARE REVISION:

From COMMAND mode, enter 0040 on the keypad. This is the start address that holds the Firmware Revision data (2 Bytes).

Enter EDIT mode.

Write down the data.

Press the F1 key to increment the address to 0041H.

Write down the data.

Press the F2 key to return to Command mode.

If, for example - the two bytes are 02H and 61H. This would correspond to FW Revision 2.61.

WRITING AN ASCII CHARACTER TO THE SCREEN:

Use the FX2A Instruction.

The CHIP-8 Interpreter has in-built Fonts for the standard 7 bit ASCII character set (20 to 7E Hex). Font size is 4 by 5 pixels.

Simply place the ASCII value in a register (V0-VF), and reference that register using the FX2A instruction prior to writing the character to the screen.

Here is a program example:

```
0200:   00E0    Clear the Screen.
        6000    Set X co-ordinate.
        6100    Set y co-ordinate.
        6241    Put the 'A' character in V2.
        F22A    Point to the A font.
        D015    Write ASCII Character.
        F000    Return to Monitor.
```

A different ASCII character can be written to the screen by changing the contents of V2.

PROGRAMS

IN THE FOLLOWING CHIP-8 PROGRAM EXAMPLES:

1. Press the F2 key to ensure that you are in Command mode.

2. Enter address 0200H. The Program start address.

3. Press the F1 key, then the 0 key to enter Edit mode.

4. ENTER THE PROGRAM at the specified addresses. After the first byte of data has been entered, the program address will automatically increment.
` Continue to enter program data. While in this mode, if the F1 key is pressed - the data will not be modified, and the current address will be incremented.

5. Press the F2 key to return to Command mode. If you have the EEPROM board installed – now is a good time to save your work using the F1,1 command sequence. Be aware that whatever was previously saved in EEPROM will be written over.

6. Press the F1 key, then the 3 key to run the program.

HEX TO DECIMAL CONVERTER

Description: Converts the Hex number at address 0003H to Decimal.
Displays the result on the screen.

Address	Program							
0200	00E0	6380	6400	6500	A500	F333	F265	F029
0210	D455	F129	7408	D455	F229	7408	D455	F000

SONG - MARY HAD A LITTLE LAMB

Description: Plays the song - Mary had a little Lamb.
Tones are stored at address 0300H.
Number of Tones(-1) at address 0209H.

Address Program

0200	6500	A300	7501	2210	3523	1204	F000	0000
0210	6000	6110	6201	F065	F017	F118	F21E	63F4
0220	6400	7401	34FF	1222	7301	33FF	1220	00EE
0300	1110	0F10	1111	1100	0010	1010	0011	1313
0310	0000	1110	0F10	1111	1100	0011	1010	1110
0320	0F00	0000						

SONG - TWINKLE, TWINKLE, LITTLE STAR

Description: Plays the song - Twinke, Twinkle, Little Star.
Tones are stored at address 0300H.
Number of Tones(-1) at address 0209H.

Address Program

0200	6500	A300	7501	2210	3536	1204	F000	0000
0210	6000	6110	6201	F065	F017	F118	F21E	63F4
0220	6400	7401	34FF	1222	7301	33FF	1220	00EE
0300	0F0F	1313	0D0D	1300	0012	1211	1110	100F
0310	0000	1313	1212	1111	1000	0013	1312	1211
0320	1110	0000	0F0F	1313	0D0D	1300	0012	1211
0330	1110	100F	0000					

GAME - TIC-TAC-TOE

Description: A game against the Computer.
Player has the first turn (X).
A wrong key press will exit the game.
To restart game - press F1,3.

D displayed = Drawn Game.
L displayed = Player Loses.
W displayed = Play Wins.

Keypad Layout: Bottom (1,2,3) Middle (5,6,7) Top (9,A,B).
F1 is Function, F2 is Reset.

Address

0200	00EE	6000	6107	A300	D011	6008	A300	D011
0210	6010	A300	D011	6018	A300	D011	6000	610F
0220	A300	D011	6008	A300	D011	6010	A300	D011
0230	6018	A300	D011	600A	6100	A301	D017	600A
0240	6108	A301	D017	600A	6110	A301	D017	6015
0250	6100	A301	D017	6015	6108	A301	D017	6015
0260	6110	A301	D017	2500	F00A	3001	1270	1400
0270	3002	1276	1412	3003	127C	1424	3005	1282
0280	1436	3006	1288	1448	3007	128E	145A	3009
0290	1294	146C	300A	129A	147E	300B	12A0	1490
02A0	F000							

0300	FF80	8080	8080	8080	4224	1824	427E	4242
0310	427E	4242	5A66	4280	8080	80F0	E090	9090
0320	E000							

0400	3C00	1268	6C0A	6001	6111	A308	D015	2514
0410	1600	3D00	1268	6D0A	600C	6111	A308	D015
0420	2514	1600	3E00	1268	6E0A	6017	6111	A308
0430	D015	2514	1600	3900	1268	690A	6001	6109

0440 A308 D015 2514 1600 3A00 1268 6A0A 600C
0450 6109 A308 D015 2514 1600 3B00 1268 6B0A
0460 6017 6109 A308 D015 2514 1600 3600 1268

0470 660A 6001 6101 A308 D015 2514 1600 3700
0480 1268 670A 600C 6101 A308 D015 2514 1600
0490 3800 1268 680A 6017 6101 A308 D015 2514
04A0 1600

0500 6600 6700 6800 6900 6A00 6B00 6C00 6D00
0510 6E00 00EE 6500 8564 8574 8584 4503 2596
0520 451E 25A0 6500 8594 85A4 85B4 4503 2596
0530 451E 25A0 6500 85C4 85D4 85E4 4503 2596
0540 451E 25A0 6500 8564 8594 85C4 4503 2596
0550 451E 25A0 6500 8574 85A4 85D4 4503 2596
0560 451E 25A0 6500 8584 85B4 85E4 4503 2596
0570 451E 25A0 6500 8564 85A4 85E4 4503 2596
0580 451E 25A0 6500 8584 85A4 85C4 4503 2596
0590 451E 25A0 00EE 6038 6101 A317 D015 F000
05A0 6038 6101 A312 D015 F000 64FF F415 F407
05B0 3400 15AE 00EE

0600 360A 1618 370A 1618 1900 25AA 6017 6101
0610 A30D D015 2514 1268 370A 1630 380A 1630
0620 1908 25AA 6001 6101 A30D D015 2514 1268
0630 390A 1648 3A0A 1648 1910 25AA 6017 6109
0640 A30D D015 2514 1268 3A0A 1660 3B0A 1660
0650 1918 25AA 6001 6109 A30D D015 2514 1268
0660 3C0A 1678 3D0A 1678 1920 25AA 6017 6111
0670 A30D D015 2514 1268 3D0A 1690 3E0A 1690
0680 1928 25AA 6001 6111 A30D D015 2514 1268
0690 360A 16A8 390A 16A8 1930 25AA 6001 6111
06A0 A30D D015 2514 1268 390A 16C0 3C0A 16C0
06B0 1938 25AA 6001 6101 A30D D015 2514 1268

06C0 370A 16D8 3A0A 16D8 1940 25AA 600C 6111
06D0 A30D D015 2514 1268 3A0A 16F0 3D0A 16F0
06E0 1948 25AA 600C 6101 A30D D015 2514 1268
06F0 380A 1708 3B0A 1708 1950 25AA 6017 6111

0700 A30D D015 2514 1268 3B0A 1720 3E0A 1720
0710 1958 25AA 6017 6101 A30D D015 2514 1268
0720 380A 1738 3A0A 1738 1960 25AA 6001 6111
0730 A30D D015 2514 1268 3A0A 1750 3C0A 1750
0740 1968 25AA 6017 6101 A30D D015 2514 1268

0750 360A 1768 3A0A 1768 1970 25AA 6017 6111
0760 A30D D015 2514 1268 3A0A 1780 3E0A 1780
0770 1978 25AA 6001 6101 A30D D015 2514 1268
0780 360A 1798 380A 1798 1980 25AA 600C 6101
0790 A30D D015 2514 1268 390A 17B0 3B0A 17B0
07A0 1988 25AA 600C 6109 A30D D015 2514 1268
07B0 3C0A 17C8 3E0A 17C8 1990 25AA 600C 6111
07C0 A30D D015 2514 1268 360A 17E0 3C0A 17E0
07D0 1998 25AA 6001 6109 A30D D015 2514 1268
07E0 370A 17F8 3D0A 17F8 19A0 25AA 600C 6109
07F0 A30D D015 2514 1268 380A 1810 3E0A 1810

0800 19A8 25AA 6017 6109 A30D D015 2514 1268
0810 360A 1828 3E0A 1828 19B0 25AA 600C 6109
0820 A30D D015 2514 1268 380A 1840 3C0A 1840
0830 19B8 25AA 600C 6109 A30D D015 2514 1268
0840 3A00 1854 6A01 25AA 600C 6109 A30D D015
0850 2514 1268 3E00 1868 6E01 25AA 6017 6111
0860 A30D D015 2514 1268 3800 187C 6801 25AA
0870 6017 6101 A30D D015 2514 1268 3600 1890
0880 6601 25AA 6001 6101 A30D D015 2514 1268
0890 3C00 18A4 6C01 25AA 6001 6111 A30D D015
08A0 2514 1268 6038 6101 A31C D015 F000

0900	4801	1618	6801	160A	4601	1630	6601	1622
0910	4B01	1648	6B01	163A	4901	1660	6901	1652
0920	4E01	1678	6E01	166A	4C01	1690	6C01	1682
0930	4C01	16A8	6C01	169A	4601	16C0	6601	16B2
0940	4D01	16D8	6D01	16CA	4701	16F0	6701	16E2
0950	4E01	1708	6E01	16FA	4801	1720	6801	1712
0960	4C01	1738	6C01	172A	4801	1750	6801	1742
0970	4E01	1768	6E01	175A	4601	1780	6601	1772
0980	4701	1798	6701	178A	4A01	17B0	6A01	17A2
0990	4D01	17C8	6D01	17BA	4901	17E0	6901	17D2
09A0	4A01	17F8	6A01	17EA	4B01	1810	6B01	1802
09B0	4A01	1828	6A01	181A	4A01	1840	6A01	1832

CHIP-8 PROGRAMMING SHEET

Program Name:
Rev:
Date:
Author:

Address	Code	Mnemonic	Comments
0200			
0202			
0204			
0206			
0208			
020A			
020C			
020E			
0210			
0212			
0214			
0216			
0218			
021A			
021C			
021E			
0220			
0222			
0224			
0226			
0228			
022A			
022C			
022E			
0230			
0232			

CHIP-8 PROGRAMMING SHEET

Address	Code	Mnemonic	Comments
0234			
0236			
0238			
023A			
023C			
023E			
0240			
0242			
0244			
0246			
0248			
024A			
024C			
024E			
0250			
0252			
0254			
0256			
0258			
025A			
025C			
025E			
0260			
0262			
0264			
0266			
0268			
026A			
026C			
026E			
0270			

CHIP-8 PROGRAMMING SHEET

Address	Code	Mnemonic	Comments
0272			
0274			
0276			
0278			
027A			
027C			
027E			
0280			
0282			
0284			
0286			
0288			
028A			
028C			
028E			
0290			
0292			
0294			
0296			
0298			
029A			
029C			
029E			
02A0			
02A2			
02A4			
02A6			
02A8			
02AA			
02AC			
02AE			

CHIP-8 PROGRAMMING SHEET

Address	Code	Mnemonic	Comments
02B0			
02B2			
02B4			
02B6			
02B8			
02BA			
02BC			
02BE			
02C0			
02C2			
02C4			
02C6			
02C8			
02CA			
02CC			
02CE			
02D0			
02D2			
02D4			
02D6			
02D8			
02DA			
02DC			
02DE			
02E0			
02E2			
02E4			
02E6			
02E8			
02EA			
02EC			

CHIP-8 PROGRAMMING SHEET

Address	Code	Mnemonic	Comments
02EE			
02F0			
02F2			
02F4			
02F6			
02F8			
02FA			
02FC			
02FE			